This document is a preliminary version of the publication:

D. Tektonidis, A. Bokma, E. Kaldoudi, A. Koumpis, From Patient Information Services to Patient Guidance Services-The iCare Approach, In: N. Bessis, F. Xhafa, D. Varvarigou, R. Hill, M. Li (Eds.) Internet of Things and Inter-cooperative Computational Technologies for Collective Intelligence, Studies in Computational Intelligence, Vol. 460, 413-431, Springer-Verlag, Berlin Heidelberg, 2013 (DOI 10.1007/978-3-642-34952-2_17, ISBN 978-3-642-34951-5

A reprint of the original publication can be retrieved/purchased from the book homepage at http://link.springer.com/chapter/10.1007%2F978-3-642-34952-2_17

From Patient Information Services to Patient Guidance Services-The iCare approach

D. Tektonidis[1], A. Bokma[2], E. Kaldoudi[3], A. Koumpis[4]

Abstract The provision of the Health services in the EU despite the evolvement of ICT follows a rather traditional path were the patient is totally dependable from his/hers doctors seeking guidance for every decision he/she needs to take related to his/her condition. The vision of the iCare approach is to provide better support to patients from the comfort of their home. This paper presents a new innovative approach to improve Patient Guidance Services (PGS). iCare approach takes full advantage of Semantic Web technologies and IoT and provides a new approach that would put the demands of the patient in the center and exploiting the available sources it will offer patient guidance services reducing dramatically the patient dependency from his/her doctors

1 Introduction

Health services across the European Union and beyond are increasingly under pressure to deliver better services with diminishing resources. Patients, quite rightly, demand a high standard of service and increasingly also convenience focused on patient needs rather than the ability of the health services to deliver. Patients, on the whole, also prefer to be supported from home, as much as possible, rather than having to travel unnecessarily to receive these services or worse still ending up in long-term care, which are neither desirable nor ultimately affordable.

[1] D. Tektonidis

Research Programmes Division, M.Kalou 6, GR – 54629, Thessaloniki, Greece dte@altec.gr

[2] A. Bokma

Centre for Electronic Commerce, University of Sunderland, Sunderland, SR6 0DD, United Kingdom, albert.bokma@gmail.com

[3] E. Kaldoudi

Democritus University of Thrace, School of Medicine, Alexandroupoli, Greece, kaldoudi@med.duth.gr

[4] Adamantios Koumpis, Research Programmes Division, M.Kalou 6, GR – 54629, Thessaloniki, Greece akou@altec.gr

People nowadays live longer and want to stay in their homes as long as they can. Given this situation there are significant amounts of patients with long-term conditions with risk factors such as cardio-vascular conditions, pulmonary conditions or diabetes to name but a few, who could more effectively be supported at home.

The vision of the iCare is to provide better support to patients from the comfort of their home by providing:

- **Advisory services** to help patients manage their conditions better
- **Monitoring services** that advise patients when they need to consult healthcare professionals and collect historic data on the patient's condition to devise more informed and better treatment plans
- **Alerting emergency services** when the patient's condition suddenly deteriorates and urgent help is needed.
- **Dependable services** that will check whether services are functioning correctly and notify patients and service provider when the connection to the patient is lost unexpectedly.

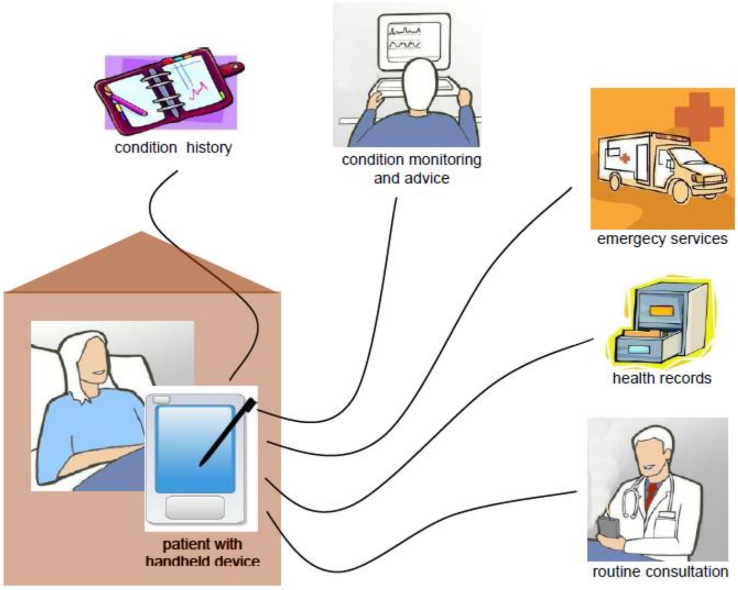

Fig. 1. iCare Patient Guidance Vision

The concept is built on the fundamental principle that patients should be supported as much as possible by easy to use technology to maintain independence through monitoring and advice and involve healthcare services when needed to address emerging problems. Nowadays IoT (Internet of Things) offers new channels and means of communication than enables our approach to be applied to additional user groups that do not have any technological background.

These monitoring and advisory services can be provided by third-party providers (and even include wireless connection to devices such as blood pressure monitors, flow meters, sugar level monitors and the like) to ensure that conditions stay within acceptable limits and offer lifestyle advice to help ease risks. This should include integration with healthcare records to provide healthcare professionals with history information for consultation and treatment. Once consultations are needed these could also be provided phone-consultation if appropriate and healthcare services be alerted when conditions escalate and patients require urgent attention.

As systems are increasingly under attack from hacking and other forms of interference it is essential that the integrity of such services can be assured, checked and that communications and data are treated as strictly confidential. Consequently, service integrity, security and appropriate data access control measures need to be part of the vision.

The iCare approach believes that making this vision reality will have a significant impact on patient care for both patients and healthcare services which go beyond what is currently available in an open service model that allows new service providers to enter and which can easily be extended to different member states independent of their current state of healthcare information technology used.

2 Semantic Interoperability for e-Health

Traditionally, healthcare professionals believed that they knew what was best for the patient [1]. In recent years another view has arisen: that patients are (and should be regarded as) the main experts on their own bodies, symptoms and situation, and this knowledge is necessary for a successful treatment. The patient should thus be treated as a partner in healthcare with both rights and responsibilities [2]. In addition, healthcare politicians and governments might hope that active patients will manage self-care better, thereby easing the economic constraints on the healthcare sector.

As early as 1977 the World Health Organisation advocated that patients participate in their healthcare [3]. Since then, there has been a focus on different ways of strengthening the patients' position in healthcare and influence over medical and treatment decisions [4].

The concepts of patient-centeredness and patient empowerment have been launched in connection with this movement, and offer opportunities for patients to increase their autonomy and involvement in decision making care and treatment [5].

These concepts are widely used and discussed in healthcare research literature, and yet they are rooted in different disciplines and ideologies. Patient-centred medicine was introduced as "another way of medical thinking" by Michael and Enid Balint in 1969 when they proposed to hold seminars on psychological problems in general medical practice [6]. This way of thinking demanded of doctors to include everything they knew about their patient and their understanding their patient as a unique human being before forming an "overall" diagnosis of the patient's illness. In this manner, it can be said that the concept of patient-centeredness originated in a psychological/psychotherapeutic framework. Since then, the concept has been supported as good medicine, yet poorly understood [7].

In contrast to patient-centeredness, the concept of empowerment did not evolve within the healthcare arena, but as a reaction to oppression and inequality within society at large. The roots of the empowerment concept can be traced back to Freire and the "pedagogy of the oppressed" [8] and philosophers like Hegel, Habermas and Sartre or critical social theory and Marxism In the context of critical social theory it involves citizen power and achievement of common goals among people [9]. Women's liberation, gay rights, disability rights and black power were all influenced by empowerment in one way or another. Within the field of healthcare, the concept of empowerment has been used on two levels. First, it has been used to describe a relationship between health and power, based on the assumption that individuals who are empowered are healthier than those who are not [10]. Secondly, it has been used to describe a certain type of patient; one who may become empowered via health education programmes initiated by healthcare systems, or one who may become empowered via their interactions with healthcare providers.

Patient-centeredness and patient empowerment are complementary concepts which do not oppose one-another. Patient empowerment can be achieved by patient-centeredness, but patients can also empower themselves. In any case, all these are mostly realized with a wealth of patient centered guidance services currently emerging in the market.

3 Healthcare System Integration issues and State of the Art

3.1 Current state-of-the-art in Integration with Personal Care Devices

Medical devices are essential to the practice of modern healthcare services. In addition to the hospitals and specialized care units, medical devices are becoming being used for remote healthcare monitoring with the latest advances in wireless communication technology. However, despite the fact that healthcare systems are becoming more dependent on specialized medical devices, the integration of these devices makes existing communication problems more complex.

In addition to the medical device connectivity problem, it is also crucial to provide seamless communication of medical device data into existing healthcare information systems – without this all non-institutional care monitoring will remain in a disconnected information silo. Similar to the extension, IHE has demonstrated this interoperation using the HL7 approved ISO/IEEE 11073 semantic payload with highly constrained HL7 protocols for the communication of vital signs observations and general sensor information. That work was based on another 11073 draft work and was demonstrated successfully in February 2007. Other work is still underway in IHE Patient Care Device Integration Profiles which aims to offer additional levels of integration using ISO/IEEE 11073 common 'MDC' language that healthcare professionals and vendors may use in communicating requirements for the integration of products.

3.2 Current state-of-the-art in Security and Privacy of Citizen Context and Electronic Health Records (EHRs)

The security and privacy of citizen's context information and EHRs depends on different concepts to be considered such as identity management, authorization, access control, trust and privacy. These concepts are already active research and development areas especially in the eBusiness domain. The major concern in eBusiness applications is the privacy of the customers. In addition, in the healthcare domain the problem is extended to providing the privacy of the records to be accessed.

For the federated identity management, in 1999, Microsoft introduced Microsoft Passport system which provides single sign-on for web sites. Then, in 2001, Liberty Alliance Project was initiated which broadens the focus of identity management with attribute federation and identity provisioning between more than one service providers. Microsoft has also initiated "TrustBridge" project in 2002 in order to provide federation in identity management however not much development has been achieved until now. OASIS Security Services Committee has published Security Assertion Markup Language (SAML) V2.0 with the contributions of Liberty Alliance and Shibboleth initiatives.

Related to the authorization and access control, OASIS Extensible Access Control Markup Language (XACML) standard and IBM Enterprise Authorization Language (EPAL) are the two major industry specifications. Both EPAL and XACML share an abstract model for policy enforcement defined by the IETF and ISO. XACML provides more features like combining result of multiple policies, ability to reference other policies, ability to return separate results for each node when access to a hierarchical resource (fine-grained access control), and support for attribute values that are instances of XML schema elements which are needed for constructing complex policies.

Today the healthcare sector is still using paper based consents usually within a single organisation with very limited patient control. For EHR sharing, the networked health information systems or individual healthcare enterprises mostly use opt-in/opt-out model which either deny the sharing of all records with outside or allows all accesses. The IHE initiative published a profile in 2006, Basic Patient Privacy Consent (BPPC), which provides more choices to patients regarding the sharing of EHR data in IHE document sharing platform. The iCare approach includes an investigation into data access management requirements and suitable technologies and it is expected to contribute to developing a robust mechanism for context and policy sensitive data access management using semantic techniques.

3.3 Semantic Web Technologies

3.3.1 Ontologies and Ontology engineering

In computer science and information science, an ontology is an explicit specification of a conceptualisation [11] or, more precisely, a formal representation of a set of concepts within a domain and the relationships between those concepts. Both meanings are relevant to iCare, because its common ontology is grounded in a particular philosophical ontology and represented as a computer-/information-science ontology. The iCare approach follows a domain ontology for healthcare services limited to the domain of the approach however in an extensible way to allow redeployment into related areas. The modelling will include not only services but also actors and policies and preferences to help manage the data access and sharing aspects.

Ontology building is supported by several methodologies proposed, in the literature. Some methodologies focus on building ontologies manually without a priori knowledge (e.g., [12]). Others are dedicated to the cooperative building of ontologies. There are also methodologies for reverse-engineering existing ontologies. And finally there are learning ontologies from various sources, such as texts, dictionaries, knowledge bases, relational schemas, XML documents etc. (e.g., [13], [14]). Another practical approach is by using constraints for cleaning initial taxonomies, as exemplified by OntoClean [15]. iCare expects to use the ontoclean approach to verify the well-formedness of the domain ontology it will use.

Ontology population is the process of inserting concept instances and relation instances into an existing ontology without changing its structure. Examples of approaches and practical systems performing ontology are Artequakt [16], the KnowItAll system [17] and SOBA [18].In the most of existing methods, instances are extracted from text which are not directly relevant to iCare, but iCare will be concerned with building bridges between the domain ontology and the underlying data model. In this case, ontology population requires a concept instance extraction toolkit which will be investigated.

Ontology languages are formal languages used to represent ontologies. The Web Ontology Language (OWL, [19], [20]) has quickly become the standard for the worldwide and the semantic web. There are three variants of OWL. OWL Full is compatible with the Resource Description Framework (RDF), but not usable for formal analysis and has different semantics from the other types of OWL. OWL DL is the maximally expressive variant that is also computationally complete. OWL Lite is intended as a lighter weight alternative to OWL DL, but is not much used in practice. Some ontology researchers use “even lighter” variants of OWL with better computational properties because, for realistically-sized problems, even OWL Lite quickly becomes computationally intractable.

Semantic annotation and meta-data is an approach to enrich information sources with additional semantic information, typically by referencing external semantic resources. Uren [21] notes that existing systems for annotating documents provide good user interfaces that are well suited to distributed knowledge sharing and enables the annotation of legacy resources but, at the same time, their support is lacking in degree of automation and range of documents covered, addressing issues of trust, provenance and access rights and resolving the problems of storage, and keeping annotations consistent with evolving documents, particularly in combination with evolving ontologies. Hence, semantic annotation is still an evolving field. There are a number of proposals for semantic annotation (or semantic mark-up) of web services. One type is METEOR-S, SAWSDL and WSDL-S, which annotate information in WSDL with ontologies. Another type is OWL-S, SWSF and WSML, which offer dedicated ontology languages for semantic web services. In [22], semantic annotation of process models is a prerequisite for semantic business process management. Some latest achievements are based on the SUPER project. The SUPER ontology is used for the creation of semantic annotations of both BPMN and EPC process models in order to support automated composition, mediation and execution. However, the annotation mechanism is based on WSMO. Semantic annotations are introduced for validation purposes, i.e., to verify constraints on the process execution semantics. In general, any enterprise model can be annotated for enabling interoperations (INTEROP 2007). iCare is watching developments in this area with interest although it is assumed that due to the safety critical nature of the application a manual intervention or at least a supervised approach may be more appropriate. The need for this may also be substantially reduced if standard case adapters are used for service development.

Semantic annotation of web-services is a common approach to support semantic web services, by linking the web-service descriptions to an ontology. For example the micro-WSMO approach [23], describe the various types of service semantics by means of a RDF Schema. Furthermore they use Semantic Annotations for WSDL and XML Schema (SAWSDL) to define a place for a semantic description in a Web service. The result of this process is an extended WSDL with additional semantic annotations that conforms an standard ontology. Another approach starts with web services that are textually specified by HTML documents. For example, SA-REST introduces semantic annotations, which are based on the RDFa ontology language, inside the meta- or container HTML elements (SPAN, DIV etc.) from a web service specification. These annotations characterize the different services, their operations and messages etc. Accordingly, Kopecky et al. [24] define the hRESTS HTML microformat, which represents a REST service functionally using the CALSS and REL HTML elements. This approach also reuses the SA-REST notation for describing the different data formats supported by the REST service. The main advantage of these approaches is that they reuse the existing textual specification and make them machine-readable. Furthermore, since REST services are described by ontologies, they can be mapped further to other format. Ontology matching is also called alignment, matching, matchmaking and mapping. Although some authors make more precise distinctions between them, we will use the term ontology matching here.

The main issue in ontology matching is to find semantic links (such as equivalence, disjointness or subsumption) between the concepts and the relations in two distinct ontologies that cover overlapping domains. The methods are based on different strategies: hierarchical clustering techniques, formal concept analysis, analysis of terminological features of concepts and relations (i.e., names or natural-language definitions) or analysis of structure [25]. Much of this issue may be addressed in iCare in the configuration phase of services and the use of a shared domain ontology reduces the need for this.

Rule based engines and semantic transformations support semantic interoperability and application integration by augmenting the ideas behind data transformation languages like XSLT with semantics. Hence, technologies that originally were used for rules definition like RuleML (http://www.ruleml.org/) and SWRL (SWRL http://www.daml.org/2003/11/swrl/) are now used to define semantic transformations. The transformation of data is defined inside transformation ontologies (SWRL) and the transformation engine also uses ontologies that define the semantics of the data. The Rule Interchange Format (RIF) is an attempt to support more complex cases and allowing m-to-n transformations. Finally, Ontorule (http://ontorule-project.eu/) use ontologies to create interoperable business rules. The execution of the semantic transformation is based on rule engines that are able to process RuleML or SWRL. There are many tools that use SWRL files directly, like SweetRules (http://sweetrules.projects.semwebcentral.org), or enhancements on Java rule engines, like JESS (http://www.jessrules.com/). These reasoning engines can be used for semantic transformation in combination with SWRL.

3.4 Semantic web services

Service-Oriented Architecture (SOA) allows applications to share common business logic or methods [26]. SOA is used to wrap legacy systems to make their functions and data more readily available within and across organisational boundaries, and to develop new systems on top of which cross-functional workflows can be established as composite services based, e.g., on agent technologies or enactable process models. The heavy focus on services in modern enterprise information architectures has led to the promotion of service-oriented computing (SOC) as a new paradigm for ICT in the private and public sectors (Cummins 2002, Gold-[27]). iCare will contribute to this area to develop a semantically enhanced web service architecture that goes beyond the interface level and focused on an integration-centric approach.

Web services are a central part of the technological platform for SOA/SOC. The W3C defines a web service as a software system designed to support interoperable machine-to-machine interaction over a network. For this purpose, the interfaces that a web service provides must be described in a machine-readable format. One central standard is the web-service description language (WSDL), which describes web services in terms of one or more interfaces defined in terms of their input and output data. Typically, methods are exchanged using the simple object access protocol

(SOAP) over TCP/IP. Web services over WSDL/SOAP are further supported by the extensive OASIS-managed “WS”-family of standards for security, privacy, transactions etc. But WSDL/SOAP is not the only platform to support web services. Other examples are regular APIs that are made available on the Internet, as well as OMG's CORBA, Microsoft's DCOM and Java RMIs. WSDL/SOAP-based web services are becoming criticised for being overly complex. In consequence, the representational state transfer (REST) principles have been proposed as a path to offering web services without the complex platforms and standards of the WSDL/SOAP family.

Although RESTful services are being touted as a light-weight alternative to protocol-heavy web services based on WSDL/SOAP, we will continue to use the term web services in a wide sense in iCare. Hence, we will use the term web services whether they are based on WSDL/SOAP or other protocols and whether they conform to RESTful principles or not.

There are several families of proposed standards for semantic web services. OWL-S uses OWL for describing the semantics of web services that are defined using WSDL, and it is itself an extension of OWL.

The purpose is to enable users and software agents to automatically discover, invoke, compose, and monitor services under specified constraints (W3C 2004). OWL-S offers some support for describing composite semantic web services that are put together from other simpler ones, and there is tool support for executing simpler services specified in OWL-S. The WSMO family is an alternative to OWL-S that is maintained by the ESSI cluster (WSMO 2009). It is not based on OWL, but consists of the web service modeling ontology (WSMO), which is a conceptual model for Semantic Web Services, the web service modeling language (WSML), a language which provides a formal syntax and semantics for WSMO, and the web service modeling execution environment (WSMX), which is an execution environment and a reference implementation for WSMO. WSMX offers support for interacting with semantic web services. Recently, metamodels were defined for two of the three prominent Semantic Web service descriptions languages. Skogan et al. [28] and Guarino et al. [15] describe a metamodel for OWL-S and Skogan et al. [28] discusses a metamodel for WSML. The Platform Independent Metamodel for Semantic Web services (PIM4SWS) can be combined with model transformations to selected individual meta-models of semantic web-service formats (OWL-S, WSML, SAWSDL) to allow transfer of information between platforms. The PIM4SWS in combination with a model-driven Semantic Web services matchmaker agent allows discovering semantic services independent of selected description formats like OWL-S, WSML and SAWSDL (Semantic Annotation of WSDL and XML Schemas). It is expected that iCare builds on the OWL-s approach and extend the standard architecture for deeper annotation of services and their integration and generate innovation in this field alongside the semantic handling of data access request (though that could also be classed separately under the heading of data access management).

4. The iCare PGS model

What patients need is to keep an eye on their conditions and receive useful advice such as reminding them to take their medication or adapt the dosage to their current situation and also lifestyle advice that may help to ease their condition where appropriate. Patients should also have available advice if they are worried that will take them through their current condition to check whether everything is fine or whether they should seek medical advice soon or immediately. This requires collecting data from patients through dialogue and/or through integrated devices (for example if a blood pressure measuring device is used with wireless connection) and keeping these records for further analysis or for making available during consultations.

To implement this scenario the advisory services need to be available to the patient via a handheld device or if too complex to be run on the device through remote access to such a service hosted elsewhere. This service needs to be integrated with healthcare systems and services as shown in figure 1 to provide the necessary connections to make available the data collected from the patient to clinicians for routine or emergency consultations and to support advisory and alerting services should the patient need assistance.

A considerable amount of technology in terms of patient monitoring is available for clinical use in hospitals and health-centres (such as Micropaq™ from http://www.welchallyn.com) to name but one) but not so much available technology has found its way into the patients home or to enable patients otherwise confined to their home to become more mobile and self-sufficient. There is huge potential to achieve improvements in quality of life while reducing direct contact with healthcare providers through the development of mobile patient monitoring and guidance services which this approach aims to address.

Our approach is based upon an open platform for mobile patient guidance services aimed at patients with long-term risk-factors such as cardio-vascular conditions, diabetes or pulmonary conditions. Mirroring the key objectives stated in the vision outlined above this can be provided through:

- the use of ***pre-diagnostic and advisory services*** the patient can use to check whether their condition is still manageable and perhaps receive also lifestyle guidance to improve their condition or stop them from deteriorating
- together with the ability to ***collect condition histories from patients for inspection*** by healthcare service staff so that the healthcare service can make improved condition management.
- ***Alerting services*** where needed to trigger healthcare service intervention so that patients who suddenly need help are spotted early and their needs attended to before they become critical.
- The services are aimed at ***helping patients manage their conditions*** and provide practical advice as well as monitoring conditions and making the history available to the healthcare service provider to make more informed decisions and intervene where conditions are suddenly deteriorating.

The benefit of this concept is to enable patients to manage their long-term conditions just as effectively from the comfort of their home and free resources including hospital beds to other patients in need of them.

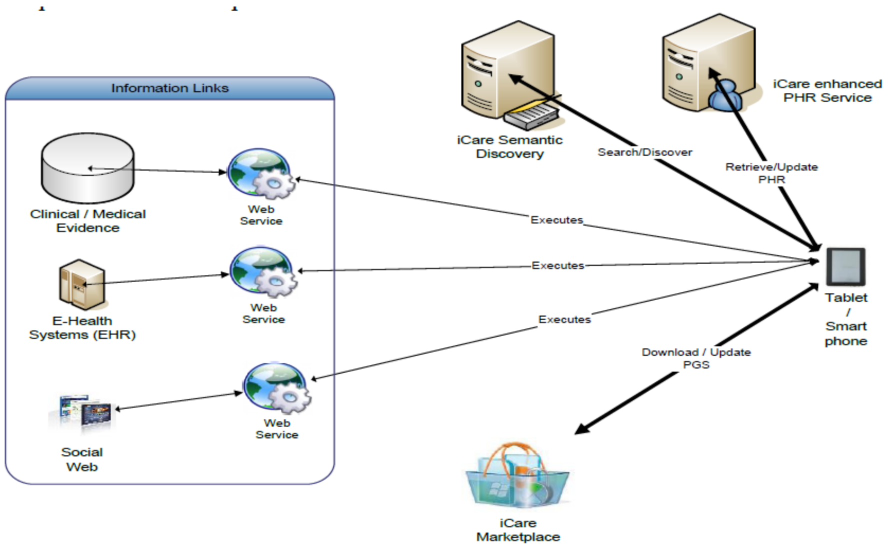

Fig. 3. iCare Patient Guidance Services

From a technical point of view, and as far as the patient is concerned, the iCare service concept is *centred on the use of standard and widespread mobile devices* such as smartphones or tablet computers and to use these to run internet based services from a variety of approved providers alongside existing devices to measure blood sugar level, pulse and blood pressure or lung capacity. The applications would then use dialogue and data entry by patients for *offering advice* and to *keep a history* used and uploading to healthcare information systems for inspection by healthcare professionals during consultation (on or off-line) and to *trigger emergency response*. The diagram below shows the technical service infrastructure where patients can download suitable services and use them to interact with relevant parties and systems to receive advice and support from a variety of approved providers.

Concerning the service concept, the iCare approach acknowledges the fact that there are a *variety of providers* and a potentially *growing number of evolving services* that need to be supported and thus proposes an open platform for service provision for ease of access from the patients and healthcare services provider's perspective. iCare also acknowledges the *sensitivity of the data* associated with treating patients and the need for suitable approaches for *security and privacy* enforcement. Consequently there is a need for an open platform that allows available services to be published and discovered and given the high degree of connectivity required a

SOA based service registry is envisaged. This platform is designed to support the following:

- Development of patient guidance service components and their correct classification using a standard iCare service adaptor
- Approval of service components for correct classification and functioning
- Exposing service components and publishing them in the iCare marketplace
- Selecting suitable services for a candidate application
- Downloading client to patient device and Composing a complex service
- İnstantiation and configuration of service at patient home and testing
- Handling service updates

The benefit of this approach is that services can rapidly be selected and configured for multi-end point services as suggested by figure 1. To this end figure 3 shows the service offerings in the iCare marketplace which is published through the iCare Semantic Discovery Registry and that can be used to access the chosen iCare enhanced PHR Service and in addition to connect to several additional services for example to upload the history data to the patient record system or connect to telemedicine services or even emergency services where available.

The approach focuses on services related to the lifestyle of patients with chronic disease and especially with cardiac and renal problems. These two groups have been chosen because these are very indicative cases of patients that require frequent consultations. Therefore a measure of success could be the reduction of the patient-doctor contact as well as the perceived quality of the service and advice from the patients' point of view.

4.1 The iCare PGS Semantic Service Platform

The provision of the services will follow the life-event model that has been implemented successfully in the past for e-Government Services[4]. The life-event approach facilitates discovery of the service because it bases the services discovery in the user profile (in iCare situation this can be the PHR of the patient) and on WHAT the patient wants to do ("My ***blood pressure*** is ***x/y*** – do I need to take more ***medication*** or do I need to see a ***doctor*** or do I need an ***ambulance*** straightaway?"). To increase the reusability and reduce the complexity of a Patent Guidance Service, iCare will divide a PGS into a set of operations/actions that the patient may require. Although these operations will be part of the PGS the will be autonomous enabling the patient to select the operations that would like to use.

As presented in figure 1, the patient will be able to download the Patient Guidance Services from the iCare marketplace according to his/her needs. The services

[4] OneStopGov project http://islab.uom.gr/onestopgov/

will be installed as Apps (Mobile Applications) to his/her mobile device (Tablet/Smartphone). The installed PGS will use data from the PHR of the patient through the iCare enhanced PHR service, the input provided by the patient and using the iCare Semantic Discovery Service will be able to locate and retrieve information from the available information link. We use the term "information link" as in Linkeddata to define every available system or service that can be accessed through the web.

The iCare Marketplace will provide a variety of patient guidance service applications that can be linked to the healthcare service and data from the PHR will be able to support patients with chronic disease reducing dramatically the dependency from their carers and improving their lifestyle.

4.2 PGS and Data Collection as Interoperability components

iCare defines Patient Guidance Service and data collection as a standalone component that conceptually is very close to the notion of mobile applications. The major issue in using a PGS is if the service can be applied to applications or systems that the patient uses. The variety of available software currently used in healthcare and of communication APIs create a very large number of different scenarios for PGS.

In iCare the usage of a service breaks down into components that are independent but which will be interoperable. To facilitate the development of such components, iCare will provide for healthcare application providers semantic descriptions of the PGS or data collection services. Following the approach of Linkeddata[5] where software systems are defined as Information Links, iCare will use Semantic Web Technologies to define the requirements of interoperability components and data access and security constraints.

It is essential that services are appropriate for the patient and that data in heterogeneous environments is handled correctly. It is also essential that appropriate safeguards about data access, privacy and security are obeyed in a context-sensitive way. This can only be achieved through the use of semantic approaches and more specifically the semantic web as we are dealing here with a web-based platform. These requirements are consequently expressed in high level semantics that define what information should be exchanged and what operation should be performed before or after the exchange. Therefore the specifications of the Interoperability Component can be defined without any dependencies from the software applications that will participate. An Information Link can participate in the operations of a PGS as long as there is a formal way to associate the semantics of the integration case (vocabulary and operations) to the integration protocol used by the Information Link.

Therefore there is a need for a semantic annotation between the semantics of the Integration Case and the semantics of the Information Link. Since the operations

[5] http://www.linkeddata.org

and the vocabulary of an Integration Case is independent from the Information Links the development of interoperability components for different Information Links is reduced to the semantic annotation and the technical mapping between the concepts and the actual data.

This facilitates the creation of Interoperability Components Marketplace that will contain predefined Integration Cases and will enable Software Development companies and Integration Companies to develop and publish interoperability components to enable interoperability of their software or software that they support. The interoperability components will be based on the semantics of the Integration Case and the semantics of the Information Link and be made available as a basis for a given application.

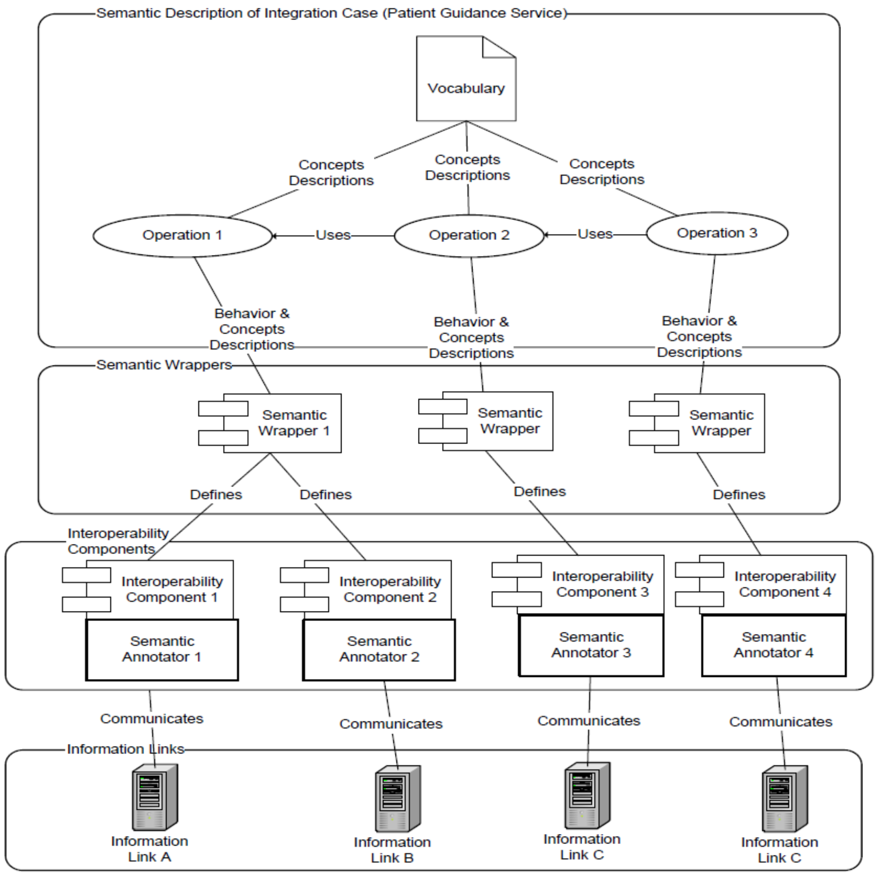

Fig. 4. iCare Patient Guidance Services Deployment Approach

In figure 4, the Patient Guidance Service is broken down into operations that are defined by a vocabulary. The vocabulary used for the definition of the service will use Semantic Web technologies such as ontologies and it will also use standards and vocabularies used in healthcare systems. For example if the PGS involves a medicine definition SNOMED[6] may be used. As aforementioned a PGS will be defined as a set of operations that the patient will be able to perform. The operation will be deployed as a Semantic Wrapper that is the software implementation of the operation. The Semantic Wrapper is a stand-alone software component that implements the behaviour and the vocabulary of the operation. The semantic wrappers can be used be smart devices so that these devices to provide and receive data from iCare.

Finally, in order a Semantic Wrapper to become an interoperability component that can be executed it requires annotation that will enable to communicate with an information link. The information link can be a software application or a web service in general that the interoperability component will interoperate. The semantic annotator will provide a bridge between the interoperability component and the service or the system that will be implemented for.

5. A new approach on Patient Guidance Services Provision- iCare Innovation and Novelty

iCare presents a new approach for the provision of Patient Guidance Services. The patient can "buy" the Services from a Marketplace (along with additional components) as an App and use it from his/her mobile device. The approach also focuses on the personalization of the services and the secure and reliable sharing of the patient data amongst the doctors that are involved in their treatment. Therefore the novelty of the approach can be summarised as follows:

- **Interoperability Components Marketplace:** For iCare both the usage of PGS and the data collection software are mobile Apps that can be downloaded from a Marketplace similar to iTunes. From the patient perspective this enables the patient to search for the PGS that are suitable to his/her occasion (treatment) and to his environment (hospital or healthcare that he/she visits). From the business perspective, iCare Marketplace want to attract not only software companies that has developed a particular e-health application (e.g. EHR) but also other companies that can develop an interoperable component for an e-health application.
- **Case based, on-demand integration.** The execution of a PGS may involve several e-Health applications. The data collection for executing the services depends on the e-Health applications that are involved. iCare introduces an "integration on demand" where the software components will be selected accord-

[6] http://www.ihtsdo.org/snomed-ct/

ing to the e-Health of each case. However the semantics of the PGS are independent from the e-Health applications. iCare enable the use of Semantic Web Technologies to define the semantics of the PGS that will provide formal (technical) conceptualization that will facilitate the development of the interoperability components.

- **Mobility and stand-alone functionality of the PHR and PGS mobile applications**. The usage of mobile device that will contain the patient data (part of the PHR) instead of using a typical online system such as Google Health or Microsoft Vault is the availability of the data. The precondition for using online PHR system is the existence of the internet connection and a computer that are not always available. iCare enables both online and offline repositories to ensure that the patient will have available his patient record at all time. The portable device will be able to connect directly to an e-Health application (hospital EHR) or device. In addition, the patient will be able use his current location data that are important to may PGS especially if the patient travels frequently.
- **Semantically enhanced integration and data protection**: The use of semantic web technology for context sensitive integration of services and the parties involved will lead to a higher degree of reliability of integrations and services fit for purpose. Current techniques are too much focused on the parameters of the interface rather than the purpose and use of the service they provide access to. In addition, the implementation of a context sensitive access control mechanism will deliver services which implement stringent data access policies.

5.1 The iCare Solution

The iCare aims to provide a complete solution to the new vision for PGS provision presented previously. In this solution the patient plays of course the main role however we believe that the success of the platform lays also to the support provided by the Platform to 3rd party companies even to SMEs that would like to include new PGS or enrich the existing ones.

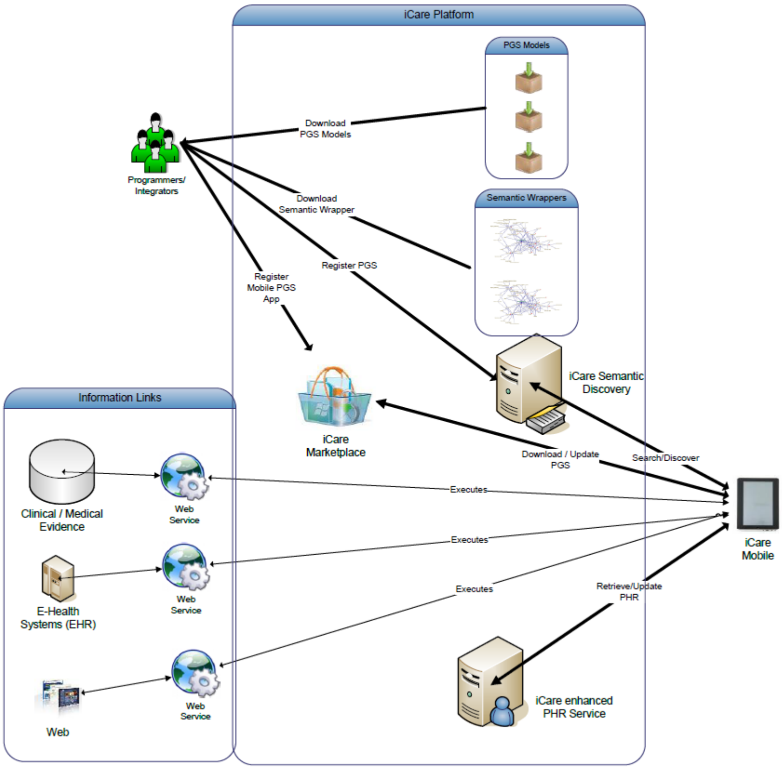

Fig. 5. The iCare Solution

The iCare solution (figure 5) aims to create and support a community of developer that will be able to communicate with the end customers (patients) through a marketplace similar to the concept of iTunes. In this respect the companies that aim to create PGS will be assisted with several tools and resources.

Therefore the iCare solution consists of the following components:

- **PGS models.** The PGS model are predefined generic models of PGSs that can be used for the developement of PGS. A PGS model contains the semantics (vocabulary) and the functionality that provides a technically defined desciption for the developer.
- **Semantic Wrappers.** The PGS will use sources from the web to acquire their information. The iCare will provide a pool of semantic wrappers that enable the annotation of a PGS to various information links. Therefore the developer needs only to technically "map" the Semantic Wrapper to the PGS in order to use the information links.
- **iCare Semantic Discovery (Search Facility).** The semantic Search facility enables the patient to search using semantic queries available PGS. The facility also enables the developers to register their PGSs defining their functionality.

- **iCare enhanced PHR Service.** iCare aims to automate the execution of the PGSs. Therefore the iCare enhanced PHR Service will communicate with iCare Mobile in order to provide only the data required for the execution of the PGS. Therefore the patient will not need to input information that already exists in his/her PHR.
- **iCare Marketplace.** The Marketplace contains all the necessary functionality to facilitate the download and installation (and update) of PGS mobile apps. iCare focuses on the simplicity of the usage of the marketplace.
- **iCare Mobile.** The iCare Mobile enables the patient to search, download and use PGS from his/her mobile. In addition, it contains functionality that requires data from his/her PHR through the iCare enhanced PHR Service.

iCare solution aims to simplify the execution of PGS. The entire solution is built upon principals that have been already applied very successfully in other domains (like mobile applications). However we strongly believe that with the usage of Semantic Web the concept of Apps Marketplace can be applied to PGSs providing an innovative approach to PGS provision.

6. Conclusions and future work

The concept of Patient Guidance Services presented by the EC aims to enhance Patient Information Services integrating information from the EHR of the patients and including sophisticated decision support services. The knowledge should be created from sources available from the Web. In this direction iCare is an approach that is based on a modular architecture that exploits Semantic Web technologies and SOA to build a system focuses on patient with chronic diseases.

The next phase of the development of the iCare approach is the integration of the main components and a pilot operation that will enable us to assess the presented architecture. The pilots will be implemented to renal and cardiac patients including advisory and alerting services before investigating more complex services.

References

1. E.J. Emanuel and L.L. Emanuel, Four models of the physician–patient relation-ship, J Am Med Assoc 267 (1992), pp. 2221–2226
2. Coulter, Paternalism or partnership? Patients have grown up-and there's no going back, Br Med J 319 (1999), pp. 719–720.
3. P. Bissell, C.R. May and P.R. Noyce, From compliance to concordance: barriers to accomplishing a re-framed model of health care interactions, Soc Sci Med 58 (2004), pp. 851–862.

4. L.M. Ong, M.R. Visser, F.B. Lammes and J.C. de Haes, Doctor–patient com-munication and cancer patients' quality of life and satisfaction, Patient Educ Couns 41 (2000), pp. 145–156.
5. P. Little, H. Everitt, I. Williamson, G. Warner, M. Moore and C. Gould et al., Preferences of patients for patient centred approach to consultation in primary care: observational study, Br Med J 322 (2001), pp. 468–472
6. E. Balint, The possibilities of patient-centered medicine, J R Coll Gen Pract 17 (1969), pp. 269–276
7. H. de Haes and N. Koedoot, Patient centered decision making in palliative can-cer treatment: a world of paradoxes, Patient Educ Couns 50 (2003), pp. 43–49.
8. N.B. Crawford Shearer and P.G. Reed, Empowerment: reformulation of a non-Rogerian concept, Nurs Sci Q 17 (2004), pp. 253–259.
9. O'Cathain, J. Goode, D. Luff, T. Strangleman, G. Hanlon and D. Greatbatch, Does NHS di-rect empower patients?, Soc Sci Med 61 (2005), pp. 1761–1771.
10. K.J. Roberts, Patient empowerment in the United States: a critical commentary, Health Expect 2 (1999), pp. 82–92.
11. Gruber, T. (1992). Toward Principles for the Design of Ontologies Used for Knowledge Sharing. In: International Journal Human-Computer Studies. Vol 43, p.907-928.
12. Gruninger, M. and Fox, M.S. (1995). Methodology for the Design and Evaluation of Ontologies, Proceedings of the Workshop on Basic Ontological Issues in Knowledge Sharing (IJCAI'95).
13. Maedche, A. and Staab, S. (2001). Ontology Learning for the Semantic Web. IEEE Intelligent Systems 16(2):72-79.
14. Babko-Malaya, O., M. Romero, L. Kallmeyer (2004). LTAG - Semantics for questions. Proceedings of TAG,Vancouver, pp186-193.
15. Guarino, N. & Welty, C. (2002). Evaluating Ontological Decisions with OntoClean. Communi-cations of the ACM 45(2):61-66.
16. Alani, H., S. Kim, D.E. Millard, M.J. Weal, W. Hall, P.H. Lewis and N.R. Shadbolt. Automatic Ontology-Based Knowledge Extraction from Web Documents, IEEE Intelligent Systems, 18(1), pp. 14-21,2003
17. Etzioni O., Kok S., Soderland S., Cagarella M., Popescu A.M., Weld D.S., Downey, Shaker T., and Yates A. (2005). Unsupervised named-entity extraction from the Web: An experimental Study, Artificial Intelligence 165:91-134, Elsevier, 2005.
18. R. Navigli, P. Velardi. Structural Semantic Interconnections: a Knowledge-Based Approach to Word Sense Disambiguation. IEEE Transactions on Pattern Analysis and Machine Intelligence (TPAMI), 27(7), July, 2005, pp. 1063-1074
19. Antoniou G. and Frank van Harmelen . Web Ontology Language: OWL. I S. Staab and R. Studer (red.) Handbook on Ontologies in Information Systems, Springer,2003
20. Horrocks, Ian, Peter F. Patel-Schneider, and Frank van Harmelen (2003). From SHIQ and RDF to OWL: The Making of a Web Ontology Language. J. of Web Semantics, 1(1):7-26.
21. Uren, Victoria, Cimiano Philipp, Iria Jose, Handschuh Siegfried, Vargas-Vera Maria, Motta Enrico, Ciravegna Fabio, Semantic Annotation for Knowledge Management: Requirements and a Survey of the State of the Art, Journal of Web Semantics, 2006, vol. 4, no. 1., pp.14-28.
22. Wetzstein, B., Ma, Z., Filipowska A., Kaczmarek M., Bhiri S., Losada S., Lopez-Cobo J., Cicurel L., Semantic, Business Process Management: A Lifecycle Based, Requirements Analysis. In: Workshop SBPM, Innsbruck, Austria, June 7, 2007, pp. 1-11.
23. Tomas Vitvar, Jacek Kopeck, Jana Viskova, and Dieter Fensel. 2008. WSMO-lite annotations for web services. In Proceedings of the 5th European semantic web conference on The semantic web: research and applications (ESWC'08), Sean Bechhofer, Manfred Hauswirth and Manolis Koubarakis (Eds.). Springer-Verlag, Berlin, Heidelberg, 674-689.

24. Kopecky, J., Vitvar, T., Bournez, C., Farrell, J.: SAWSDL: semantic annotations for WSDL and XML schema. IEEE Internet Computing 11(6), 60–67, 2007.
25. P. Shvaiko, J. Euzenat, A. Leger, D. L. McGuinness, H. Wache (eds.): Contexts and Ontologies: Theory, Practice and Applications (C&O-2005) Proceedings of the AAAI'05 Workshop C&O-2005, AAAI Press, 2005.
26. David Linthicum "Next Generation Application Integration: From Simple Information to Web Services", Addison-Wesley 2003, ISBN: 0201844567, USA
27. Bernstein B and Ruh W., Enterprise Integration, Addison Wisley, ISBN 0-321-22390-X, 2005
28. David Skogan, Roy Grounmo, Ida Solheim, Web Service Composition in UML, The 8th International IEEE Enterprise Distributed Object Computing Conference (EDOC), Monterey, California. September 2004

Index of Terms